"1923 is destined to repeat something like the experiences of 1315, the year of the worst and most general harvest failure known in European history." To the crowd, if not to the man of science, the fulfilment of a prophecy always seems to give more adequate support to a theory than any number of agreements with past events, and the year 1923 may be awaited with an interest mingled with anxiety. On the face of it, the evidence seems sound, and the reasoning careful and critical.

Sir William Beveridge does not attempt to trace the physical causation of the observed periodicity further than to show that it may be accounted for by cycles already noted in meteorological or astronomical data. The eight-year period gives only a small maximum in his periodogram with an intensity of 12. Years after 1844 were apparently omitted in part because during the nineteenth century the character of the curve visibly alters, the "credit cycle" acting as a "disturbing influence." It may, however, be questioned, in view of Prof. Moore's work, whether the credit cycle can be treated in this way as an extraneous disturbing cause. An eight-year cycle, as he says, was isolated in the barometric pressure of the United States, and has also been traced in rainfall, and these cycles appear to be congruent with the economic cycle. When Prof. Moore goes beyond this and seeks for a cosmic cycle that may be regarded as the "generating cycle," he lights on an hypothesis for which, we think, a good deal of further evidence will be required before it can win acceptance; it is suggested that the period in question is that between conjunctions of the earth and Venus. No proof, however, is given that the periods coincide with any precision, the periodograms for economic data having been calculated only for integral periods.

Analysis must be carried further before a true consonance of the periods can be predicted with any confidence. The point brought out by Sir William Beveridge, moreover, that the period in the weather may not be that in the yield of the crop, must be borne in mind. If a "maximum" of some kind in the weather is vital to the crop only provided that it occur at some critical period of the year, the determination of this critical period becomes of interest, and we would suggest that such work as that of Mr. R. H. Hooker, of the Ministry of Agriculture, whose presidential address to the Royal Meteorological Society on the correlation in eastern England between yield and the weather in successive months of the year was summarised on p. 193 of Nature for February 9, might help to elucidate the matter. Crop prediction is a matter of the highest economic importance, and all lines of investigation should be considered together.

A Searchlight on Solids.

Aggregation and Flow of Solids: Being the Records of an Experimental Study of the Micro-structure and Physical Properties of Solids in Various States of Aggregation, 1900–1921. By Sir George Beilby. Pp. xv + 256 + 34 plates. (London: Macmillan and Co., Ltd., 1921.) 20*s*. net.

THIS is a book that will hold a true child of science like any fairy-tale, and it would be difficult to overstate its fascinating interest. In form, in substance, and in all its auspices it is so highly individual. It is a story, a connected story, of the leisure pursuits of one of our leading and most enlightened industrialists, who for many years, and pre-eminently in the stress of war, has rendered great services to his country. But it is a record that would adorn a life wholly devoted to the pursuit of science.

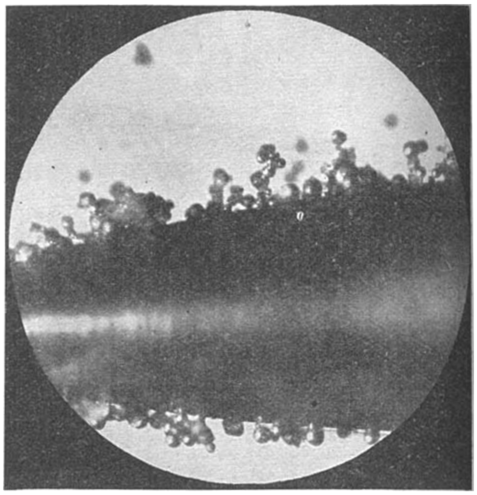

Fig. 1.—Globules of zinc dust picked up on the edges of a thin steel blade (× 60). From "Aggregation and Flow of Solids."

All who are seriously concerned with physical or chemical science must know something of the contributions which Sir George Beilby has made to the subject dealt with in this book, but the rush of scientific discovery makes it very difficult to realise the full sweep and significance of much that is going forward. Probably every one knows that Sir George Beilby has demonstrated the existence of a vitreous state in metals and other solids where that state had never been suspected, and to most of us he has become permanently "featured" on the transparent *surface film* of polished solids.

In his papers from time to time he has disclosed in some degree the theoretical accompaniment and the connecting threads of his experimental work, but it is probable that few will have seen the extraordinary breadth and comprehensiveness of the ideas which have developed as the work proceeded, or have realised the extent of their implication in matters of great scientific and practical importance.

The work under notice now tells the whole tale in a form which leaves nothing to be desired, and adds at least one new chapter. It is not difficult to understand how much it must have cost of resolution and hard labour to bring to its present form the vast amount of material that had accumulated in Sir George Beilby's hands, and we must all be grateful to Sir Herbert Jackson, whose persuasiveness brought Sir George Beilby to the point of setting out on his task, and whose help, along with that of Mr. W. D. Haigh, is very gratefully acknowledged by the author. "I unhesitatingly say," he states, "that without his (Mr. Haigh's) constructive skill and insight the work would not have been accomplished." And we may add that no one more than Sir Herbert Jackson was in a position to appreciate the importance of Sir George Beilby's work.

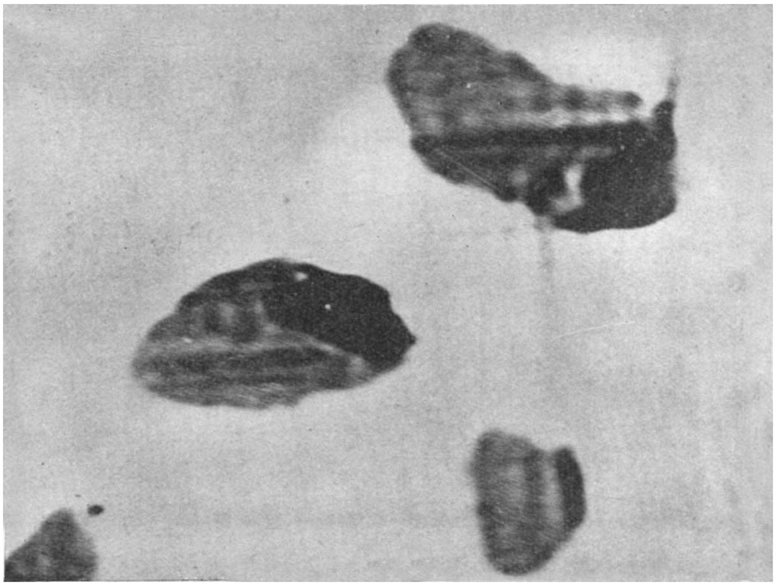

FIG. 2.—Crystalline antimony polished by emery and rouge and etched with potassium cyanide, showing film of flowed metal covering pits. From "Aggregation and Flow of Solids."

The letterpress extends over some 250 pages, clearly printed and in every respect easily readable. The concluding part consists of thirty-four beautiful reproductions of a series of figures, nearly all photographic. Not one of them is uninteresting, and most of them are remarkable. In the letterpress the topics dealt with in sequence are the following: Microscopic methods and measurements; surface tension films in liquids and solids; the varied ways in which aggregation takes place; cohesion among minute solid particles and between these particles and flat surfaces; polish, the result of surface flow; the crystalline and vitreous states in solids; influence of the crystalline and vitreous states on the physical and mechanical properties of ductile metals; influence of the crystalline, mobile, and vitreous states on the flow of rocks and ice; molecular pulsation cells: a tentative hypothesis; extension of Faraday's work on the optical and other characteristics of thin metal leaves; phosphorescence of crystals effected by the change from the crystalline to the vitreous state.

The general nature of Sir George Beilby's work can probably be best understood by thinking of the conditions under which it was carried out. We have to picture a man of scientific taste and talent, whose lot has been cast in the industrial world, eager to devote his leisure to the advancement of fundamental knowledge and compelled to select a topic that can be cultivated experimentally under home conditions, that do not give any very exceptional facilities for experimental work. Under these limits, what better than to take up the study of some topic of micro-chemistry or micro-physical chemistry? Able to provide himself with the best appliances for his purpose, and skilled in the manipulative art of the chemist, he develops a highly special technique, and with all these resources applies himself to particular problems of his subject. The result is a series of refined observations and delicate manipulations which has disclosed many things never seen before and established many new facts about the structure and behaviour of solids.

It is really very difficult to give a summary of what is contained in this book. It would be rather like writing a short paragraph summarising the incidents of an Antarctic explorer's voyage of discovery. No doubt it is possible to say, in a word, that the centre of Sir George Beilby's doctrine is the vitreous film of solids, but the great interest of the book lies in the record of successive experimental steps by which the facts have been established and amplified. To the student of molecular physics, the metallurgist and engineer, the geologist, the fine artificers of glass and metal, the records have something of first-rate importance to say.

The present writer is probably not singular in having felt surprise on first learning that the final perfect polish of glass or metal was produced by the use of an abrading agent. One could understand the finer and finer scratches of grinding giving a greater and greater smoothness, and it was possible in the mind to conceive the *ad infinitum* refining of scratches to the attainment of a perfect sheen. But in actual practice, with a last abrasive even so fine as particles of rouge, it seemed as if there must somehow be a jump at the end between these earthy scratches and the perfect polish of speculum or plate glass. The practical attainment of such a polish seemed much more easily understood when a custodian of some of the finest old silver at Cambridge, on being asked how the brilliance was produced, simply exhibited the flesh side of an ample thumb, with a gesture and mien indicative of a *flattening* pressure exerted steadily through the ages. Sir George Beilby now tells us, and it is a relief to know it, that the microscopically differentiable particles of rouge are smaller than we thought, that they are also much harder, and that when they are spread over a leather they present a layer such that when the leather is passed over the glass or metal surface, this is *seized* as a whole, the mobility of a liquid is temporarily produced, and when the leather has passed, a film is left with all the qualities of matter that has set like melted glass. Not only so, but "whilst to produce 'mass flow' in the hardened steel of which a razor is made a differential pressure of hundreds of tons per square inch would be required, yet the 'surface flow' necessary to keep the edge of the razor in perfect cutting condition can be effected by lightly stropping the blade on the bare hand a few times daily, before and after use!"

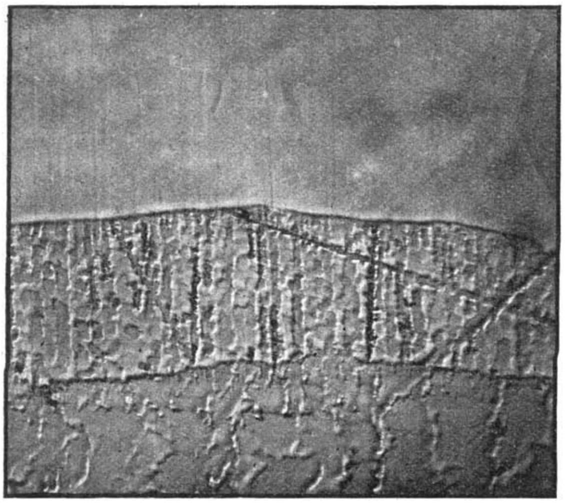

FIG. 3.—Etched calcite surface showing the untouched skin and the under surface at 500 and 1000 $\mu\mu$. From "Aggregation and Flow of Solids."

These examples are perhaps sufficient to indicate why and how this work on the surface leads to a study of the hard and soft state in metals, the flow of rocks and ice, the phosphorescence and triboluminescence of solids, and many other things besides.

A word must be said about the magnitudes dealt with in the investigations. The study of a calcite surface will suffice as an illustration:—

"When a condensed beam of sunlight was used to give oblique illumination of the surface, it was possible to detect the effect of a drop of acid which contained only 0·000125 per cent of HCl. The depth of the layer removed did not exceed 0·62 $\mu\mu$. . . . If it is correct to assume that the solvent effect of the acid was uniformly distributed over the whole surface of the pit, then it follows that a roughening of the surface not more than two molecules in depth has been detected." Again, "the mechanical disturbance caused [on calcite] by the polishing agent penetrates to a depth of 500 to 1000 $\mu\mu$."

The frame of reference of Sir George Beilby's thinking has been almost wholly that which preceded subatomism. In a short chapter he sketches his tentative working hypothesis of molecular "pulsation cells." Of this it must suffice to say that it has clearly served its purpose, for it has worked—it has led to a solid output of new knowledge. "Cohesion" is isolated in the old way as a force *sui generis*, and a fine picture is made of cohesion holding matter together in a dead world until there comes the advent of heat "like the first breath of approaching spring into the sleeping buds." Sir George Beilby has brought his rich gift of facts up to the frontiers of the newer physical science. It must obviously engage the interest of those on the other side. There are especially to be mentioned the Braggs, the work and views of Langmuir, and the new light on lubrication coming from W. B. Hardy's experiments. But whatever may be added, the facts remain as a remarkable addition to scientific knowledge.

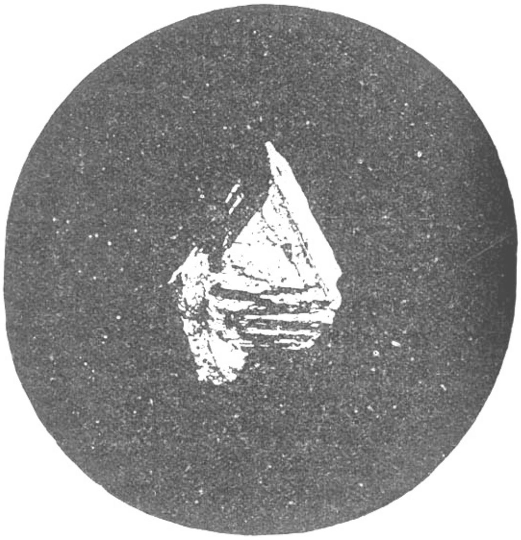

FIG. 4.—Microscopic crystal of antimony. From "Aggregation and Flow of Solids."

In conclusion, one or two suggestions may be made.

As to faults, there is need of revision at the beginning of the book in reference to the characteristic of the boiling-point. There is no index, and though one can see the peculiar difficulty of indexing this book, the omission is an inconvenience. It seems worth considering whether enlarged copies of the beautiful photographs which illustrate the book might not be issued so that they could be framed and hung on class-room walls.

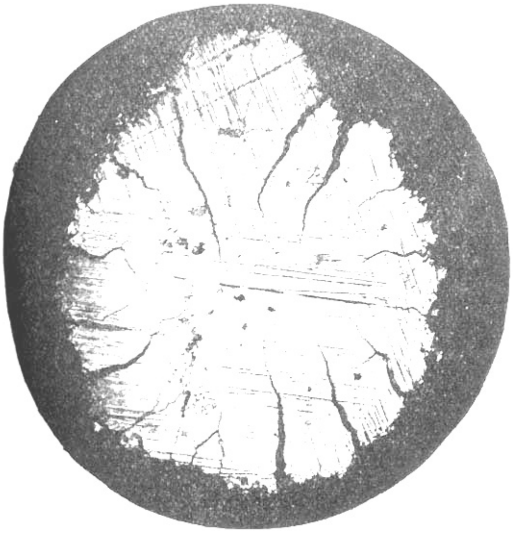

FIG. 5.—The crystal of Fig. 4 flattened by a single blow from a small drop-hammer; the thin plate was in a highly strained condition and the cracks developed in 24 hours. From "Aggregation and Flow of Solids."

A last suggestion, offered to teachers, is that this book should be freely prescribed to students of physical science. It seems very important in times with so strong an atmosphere of relativity and with *quanta* to some of us almost more than *suff.*, that students should see how much may still be accomplished by a faithful, indefatigable experimenter, who, with full knowledge, yet without prejudice, will scrupulously examine what lies positively and immediately in front of him.

A. SMITHELLS.

Pictish Stone Circles.

On Some Antiquities in the Neighbourhood of Dunecht House, Aberdeenshire. By the Rt. Rev. Dr. G. F. Browne. Pp. xiv + 170 + 63 plates. (Cambridge: At the University Press, 1921.) 63*s.* net.

DUNECHT HOUSE, Aberdeenshire, became known to science by the researches of Drs. Copeland and Lohse at an observatory established there by the Earl of Crawford. The district so thoroughly examined by the distinguished author of this superb book is that of Lady Cowdray's Scottish estate and the immediate surroundings, a district known as " 'twixt Don and Dee."

Confining my remarks to the subject which is given the largest space in the book, there is in the district of Dunecht a "large number of stone circles unique in type" (p. 1), the characteristic feature being a tangential alignment, generally in the south-west quadrant, made by a recumbent stone and its upright flankers. Of these circles Sir Norman Lockyer examined twenty-nine, and in fifteen instances he found a clock-star alignment at right angles to the recumbent stone. He discovered, in fact, the key to this unique type of circle. In my opinion, the glory of Dr. Browne's work on the Dunecht circles shines in the fact that in it the typical Pictish temple thrown open by Sir Norman Lockyer may now be inspected to the smallest detail.

A happy inspiration led the author to appeal to the Principal of the University of Aberdeen for a survey to be made of three circles, using the recumbent stone and flankers as a tangential base line, and measuring the alignment made by each stone with the middle of the recumbent stone. The survey was made by Drs. Fyvie and Geddes, and the circles were those of Midmar, Castle Fraser, and Sin Hinny (Sunhoney). It is most fitting that the three plans form Plate I.

Realising the importance of Dr. Browne's contribution to science, I have examined the seven plans of circles given in the book, and find that the alignments of the other four are also to be interpreted from the recumbent stone, the evidence being alignments in pairs at right angles to each other.

The whole truth, partly discovered by Sir Norman Lockyer, seems to be this: In the Pictish type of circle all alignments must have been originally made in pairs at right angles to each other. Finding this first, or fundamental, principle of circle-building fully established in each of the seven cases examined, I have applied that principle to test the present condition of each circle. By such a test six circles are found to be defective, and I think it is quite possible, theoretically, to restore the defective parts.

It is most fortunate that one circle is perfect according to the revealed Pictish standard, and that is Auchquhorthies (p. 69). It consists of a recumbent stone and flankers and nine other stones (the three stones on the inner side of the recumbent stone had probably some supplementary use). The outer sides of the flankers are aligned with the recumbent stone, but on their inner sides they have separate alignments which rank in the rectangular scheme of the circle and, with those of the nine out-lying stones, have a common base at the middle of the recumbent stone. The twelve separate alignments made by the twelve stones of the circle proper present six pairs of complementary measures. To obtain this result it is necessary